Reply to "Comment on 'Fluctuation-induced first-order transition in p-wave superconductors' "

Qi Li,[1] D. Belitz,[2] and John Toner[2]
[1] *National Institute of Neurological Disorders and Stroke, National Institute of Health, Bethesda, MD 20892*
[2] *Department of Physics and Institute of Theoretical Science, University of Oregon, Eugene, OR 97403*

(Dated: November 19, 2012)

PACS numbers: 64.60.ae,64.60.De,74.20.De

We regret the inaccuracies, and especially the omission of pertinent references, in our paper,[1] which are pointed out in D.I. Uzunov's Comment,[2] the technical aspects of which we agree with. Accordingly, we would like to make the following four corrections to Ref. 1.

(1) The end of Sec. III.A, starting after Eq. (3.3) and including Fig. 1, should read

We now need to distinguish between two cases.

Case 1: $v > 0$. The free energy is minimized by either $\hat{n} = \pm\hat{m}$ and arbitrary ϕ, or by $\phi = k\pi/2$, $k = 0, \pm 1, \ldots$ and arbitrary $\hat{n}\cdot\hat{m}$,[3–6] The condition $u > 0$ must be fulfilled for the system to be stable.

Case 2: $v < 0$. The free energy is minimized by $\hat{n} \perp \hat{m}$ and $\phi = \pi/4$, and $\psi_0 = -t/2(u+v)$. The condition $u + v > 0$ must be satisfied for the system to be stable.

Phases with $\boldsymbol{\psi}\times\boldsymbol{\psi}^* = 0$ and $\boldsymbol{\psi}\times\boldsymbol{\psi}^* \neq 0$ are sometimes referred to as unitary and nonunitary phases, respectively. In all cases, mean-field theory predicts a continuous transition from the disordered phase to an ordered phase at $t = 0$. The mean-field phase diagram in the u-v-plane is shown in Fig. 1.

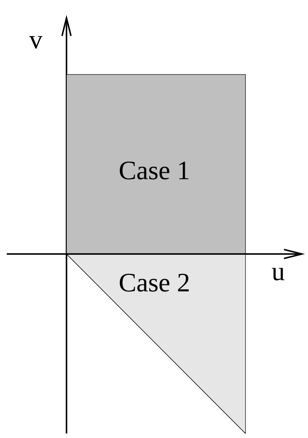

FIG. 1: Mean-field phase diagram of a p-wave superconductor as described by Eq. (2.1). See the text for additional information.

(2) The text after Eq. (3.5) should read

Here $w \propto (\mu q^2)^{3/2}$ is a positive coupling constant whose presence drives the transition into any of the ordered phases first order. In addition, the parameters t and u acquire dependences on μq^2, as is the case for s-wave superconductors.[7]

(3) Equations (3.7), the sentence preceding them, and the paragraph following them, should read

Defining $\tilde{u} = u + v$, and $\tilde{v} = -v$, we find the RG recursion relations

$$\frac{dt}{dl} = (2-\eta)\,t + 3\,c\,q^2\mu + \frac{(n+2)\tilde{u} + 4\tilde{v}}{t+c}\ , \tag{3.7a}$$

$$\frac{d\tilde{u}}{dl} = (\epsilon - 2\eta)\,\tilde{u} - \frac{(n+8)\tilde{u}^2 + 8\tilde{u}\tilde{v} + 8\tilde{v}^2}{(t+c)^2} - 3\,c^2q^4\mu^2, \tag{3.7b}$$

$$\frac{d\tilde{v}}{dl} = (\epsilon - 2\eta)\,\tilde{v} - \frac{n\tilde{v}^2 + 12\tilde{u}\tilde{v}}{(t+c)^2}\ , \tag{3.7c}$$

$$\frac{dc}{dl} = -\eta\,c - 3\frac{c^2q^2\mu}{t+c}\ , \tag{3.7d}$$

$$\frac{d\mu}{dl} = \eta_A\,\mu - \frac{n}{6}\,\frac{(3t+c)c^3q^2\mu^2}{(t+c)^4}\ , \tag{3.7e}$$

$$\frac{dq}{dl} = \frac{1}{2}\,(\epsilon - \eta_A)\,q\ . \tag{3.7f}$$

Here $l = \ln b$ with b the length rescaling parameter, we have redefined $4\pi\mu \to \mu$, and we have absorbed a common geometric factor in the coupling constants u, v, and μ. These flow equations were first derived by Millev and Uzunov,[8] and later generalized to include effects of quenched disorder.[9] For $v = 0$, they reduce to those of Ref. 7, as they should.

(4) In the remainder of the paper, u^* and u_0^* should be interpreted as $\tilde{u}^*$, and v^* and v_0^* as $\tilde{v}^*$.

[1] D. B. Qi Li and J. Toner, Phys. Rev. B **79**, 054514 (2009).
[2] D. I. Uzunov, Phys. Rev. B **xx**, xxxx (2012).
[3] G. E. Volovik and L. P. Gorkov, Pis'ma Zh. Eksp. Teor. Fiz. **39**, 550 (1984), [JETP Lett. **39**, 674 (1984)].
[4] G. E. Volovik and L. P. Gorkov, Zh. Eksp. Teor. Fiz. **88**, 1412 (1985), sov. Phys. JETP **61**, 843 (1985)].
[5] K. Ueda and T. M. Rice, Phys. Rev. B **31**, 7114 (1985).
[6] E. J. Blagoeva, G. Busiello, L. D. Cesare, Y. T. Millev, I. Rabuffo, and D. I. Uzunov, Phys. Rev. B **40**, 7357 (1990).
[7] B. I. Halperin, T. C. Lubensky, and S.-K. Ma, Phys. Rev. Lett. **32**, 292 (1974).
[8] Y. T. Millev and D. I. Uzunov, Phys. Lett. A **145**, 287 (1990).
[9] G. Busiello, L. D. Cesare, Y. T. Millev, I. Rabuffo, and D. I. Uzunov, Phys. Rev. B **43**, 1150 (1991).